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# Book Review

## Fundamentals of Rock Mechanics

*Geofluids (2009) **9**, 251–252 Jaeger, J.C., Cook, N.G.W., Zimmerman, R.W., 2005. Blackwell Publishing, Malden, Massachussetts, USA 475 pp.*

During the past 40 years, the first three editions of Jaeger and Cook's *Fundamentals of Rock Mechanics* have served as a standard textbook for students and an indispensible reference book for professionals in earth science and geotechnical engineering. For a number of years, the text was out of print. However, with the publication of the fourth edition, revised and expanded by the additional co-author Professor Robert Zimmerman, this book will again take its place as the premier text in rock mechanics.

In addition to adding new material, Zimmerman has revised large portions of the book with a fine-toothed comb. The revisions not only update material that was largely written in the 1960s and 1970s but also bring a consistency in style and notation throughout the book. The introductory discussions of many topics have been expanded to more fully describe the context and motivation behind the methodologies and approaches. Even those sections dealing with classical, well-established topics such as linear elasticity have been revised to improve clarity. For example, in the First through Third Editions, isotropy is described as follows: 'In an isotropic solid the principal axes of stress and the principal axes of strain ... must coincide'. This rather terse description does not mention the 'independent of direction' aspect of isotropy. In the Fourth Edition, the revised text is as follows: 'An isotropic solid can be loosely defined as one in which all directions are ''equivalent''. In other words, in an isotropic rock, the relationship between vertical stress and vertical strain is the same as that between horizontal stress and horizontal strain, etc'. Although more wordy, the revised text provides a more detailed and insightful explanation that particularly benefits those readers without prior exposure to the topic.

The present edition presents mathematics in both vector/matrix notation and the *x-y-z* component form, thus providing both compactness and detail. Components of the stress tensor are expressed as $\tau_{xx}$, $\tau_{yy}$, $\tau_{xy}$ instead of the old-fashioned $\sigma_x$, $\sigma_y$, $\tau_{xy}$. Again, such revisions give a more modern and systematic presentation.

After an introductory chapter, the book launches into the core subjects of rock mechanics: analysis of stress and strain (Chapter 2), friction on rock surfaces (Chapter 3), deformation and failure of rock (Chapter 4), linear elasticity (Chapter 5), and laboratory testing of rock (Chapter 6). Particularly noteworthy are the inclusion of finite strain in Chapter 2, effect of pore fluids in Chapter 4, and strain energy theorems in Chapter 5. These five chapters (about one-third of the book), plus some of the solutions for stresses around cavities and excavations (Chapter 8), can readily occupy a one-semester course in rock mechanics. Students who complete such a curriculum will have gained a solid foundation for further studies and research in geotechnical engineering.

Of particular interest to readers of *Geofluids* are two new chapters in the present edition: Chapter 7 on poroelasticity and thermoelasticity and Chapter 12 on hydromechanical behavior of fractures. In Chapter 7, the theory of poroelasticity is introduced via the more restrictive theory of hydrostatic poroelasticity, which is applicable for processes in which the pore pressure and confining pressure vary independently. Although this approach might appear somewhat roundabout, it clearly illustrates the different types of compressibility that can be defined for a mixed system of minerals and pore fluids. (These compressibilities are related to the more traditional Biot–Willis poroelastic constants.) After presenting the general theory of poroelasticity, Chapter 7 covers the classical analysis of one-dimensional consolidation and some two-dimensional solutions developed in the seismology field. The chapter ends with a section on thermoelasticity, pointing out the analogy between temperature diffusion and pore pressure diffusion.

Chapter 12 primarily treats the hydromechanical behavior of a single fracture. The important results of the past 30 years of experimental and theoretical research are covered, including stochastic representation of fracture-surface morphology, fracture behavior under normal and shear stresses, hydraulic properties (transmissivity) of fractures, coupled interaction between fluid flow and rock stress, and the influence of fractures on the propagation of seismic waves. The discussion develops from the viewpoint that 'the behavior of single fractures must be thoroughly understood before the behavior of fractured rock masses can be understood', and therefore tends to focus on how the geometry of fracture void spaces controls various hydromechanical behaviors. While such detailed analyses are undoubtedly of fundamental importance, their practical applicability is sometimes uncertain. For example, solving the Stokes equation (or its simplification) to determine the transmissivity of a rough-walled fracture becomes impractical when applied to

a field setting. Instead, hydraulic tests (e.g. pressure injection tests) are the usual method for determining fracture transmissivity in the field. Readers will have to look elsewhere for such information. Chapter 12 ends with a summary of approaches to characterize the bulk properties of fractured rock masses based on knowledge of fracture properties, orientations and spacing, using effective media theory and computer simulation.

More advanced topics covered by the book include inelastic behavior, micromechanical models, and wave propagation in rocks (Chapter 9 to 11). These chapters present basic theory and are illustrated by analyses of various distinguishing characteristics, such as plastic flow of rock, effects of pores and cracks on rock properties, and surface and interface waves. Readers wishing to delve into these more complicated rock behaviors will particularly appreciate these chapters, which will provide them with a thorough introduction, before consulting more specialized texts.

In summary, the Fourth Edition of *Fundamentals of Rock Mechanics* is clearly the result of a labor of love by Professor Zimmerman to modernize a classic text. This book is a highly valuable resource to students, researchers, and practitioners. Owners of previous editions should not hesitate to place this new edition along side of their older, probably well-used copy.

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